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DELINEATION OF SEA FLOOR ROUGHNESS IN THE WESTERN NORTH ATLANTIC

by

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INTRODUCTION

The increasing importance of having detailed knowledge of sea floor macro- and micro-topography has led to a study of six areas of the North Atlantic Ocean (Fig. 1). Five of these areas are contiguous and concentrated along the western margin, the sixth, a detailed grid study, was made in the eastern Atlantic Ocean.

The usefulness of 12 kc echo sounder data in the prediction of bottom loss has been discussed by Bryan (1964), Bryan and Ewing (1964) and Bryan and Markl (1966). In addition to echo sounder data, seismic reflection profiler records have recently been used extensively because of the excellent resolution of the water-sediment interface now being obtained with that equipment. As in previous work, areas of the sea floor are indicated by A, B, and C designations based principally on bottom roughness and texture (see Fig. 9). A, B, and C types have been defined previously as:

A Locally and regionally smooth (abyssal plains)

B Locally smooth but regionally rough

C Locally and regionally rough (usually areas where basement crops out)

AB and BC symbols imply intermediate degrees of roughness; A+C indicates that both very smooth and very rough topography coexist and that there is not enough information available to separate the two. The A, B, and C designations correspond to low, medium, and high bottom loss. Quantitative loss estimates corresponding to these letter designations are available in the above references. In areas of smooth bottom, seismic reflection profiles and sediment core samples provide a means of defining the influence of sub-bottom structure and sediment type on bottom loss.

Detailed reports on the individual areas are being prepared by other workers at this Observatory. These reports will provide fundamental information concerning the sediment types and the geologic structure and evolution of the individual areas. The following brief descriptions and maps outlining areas by degree of bottom roughness are initial products of these forthcoming reports.

DESCRIPTIONS OF AREAS

Figure 2 includes the northwestern part of the Demerara Abyssal Plain (labelled A) and a very large sediment-filled east-west trough, probably a fracture, just to the north, at about 17°N. The Demerara Abyssal Plain is bounded on the northwest by a ridge (labelled C) which is the southern wall of the trough. Most of the filling of the trough probably occurred during the Pleistocene glacial periods when vigorous turbidity currents, apparently from the Amazon Delta, overflowed the Demerara Abyssal Plain, eroding a large canyon in the process. The canyon (labelled B) enters the trough near its eastern end; the sediments flowing through it have built a smooth plain that slopes evenly to the western end for a distance of about 250 miles.

Cores taken from the floor of the canyon and from the floor of the trough penetrated a few meters of pelagic lutites and bottomed in sand. The presence of the lutite indicates that a substantial period of time has elapsed since the last turbidite flow. Cores from the Demerara Abyssal Plain typically contain lutite with silt layers and manganese common in the upper portion.

Figure 3 shows an area including the northern tip of the Nares Abyssal Plain and extending toward the southeast. The dominant topographic feature in this area is a long ditch, undoubtedly a fracture, which has been partially filled by sediments overflowing the Nares Plain. The fracture, called the Conrad fracture, has been traced for a distance of about 600 miles into the abyssal hills province (shown as C-type topography). The sediments in this fracture have formed a very smooth, gently sloping surface as did those in the 17° trough. Despite comparable smoothness, the reflectivity of this plain may not be as high as plains nearer continental areas. The seismic profiler data suggest that the turbidites in this area do not have as high a percentage of coarse material. This is undoubtedly a consequence of proximity to the source area. The 17° trough is much nearer its source area, the Amazon Delta, and therefore received an abundance of sand.

Figure 4 includes the Bermuda Rise, a large elevated region surrounded on the north and east by the Sohm Abyssal Plain and on the west by the Hatteras Abyssal Plain. It is flanked on the south by the Nares Abyssal Plain and between the Nares and the southern extension of the Sohm, by an area of abyssal hills.

The Bermuda Rise is divided into two parts; the central and northwestern portion of the rise is represented by a B-type sea floor which is occasionally pierced by peaks of basement. The southern and southeastern portion (shown as BC) is characterized by greater regional roughness which is due primarily to the thinner sediment cover overlying the rough basement topography.

All of the abyssal plains (labelled A) are very smooth and are composed of densely stratified abyssal turbidites - bottom loss in these areas should be quite low. In the southern extension of the Sohm Plain, labelled A+C, the turbidites interfinger with numerous protruding peaks of basement rock. Farther south, and labelled as C-type, is the abyssal hills province, the roughest topographic region in the North American Basin. Unconsolidated sediments are quite thin here, but isolated smooth pockets of ponded sediments do exist locally. To the east the abyssal hills merge with the similarly rough western flank of the Mid-Atlantic Ridge.

Figure 5 shows an area which includes the shallow Blake Plateau, part of which is quite smooth and part roughened by current scour, the Blake-Bahama Outer Ridge and Basin system, and the western margin of the Hatteras Abyssal Plain. This region has been studied in detail by Bryan and Markl (1966) from the standpoint of the microtopography peculiar to it. Areas exhibiting microtopography are indicated as stippled zones. These zones frequently cut across the macrotopographic (A, B, C) boundary lines. Therefore, for example, in an area indicated as A-type (very smooth and with corresponding expectation of low bottom loss) the presence of microtopography may be expected to increase loss to the equivalent of B or even C-type areas.

Figure 6 is continuous with Figure 5 and shows an area of the continental slope and rise in the region between the Hudson and Hatteras Canyons. A prominent terrace (labelled A) has been constructed in this area by the ponding of turbidites between the continental slope (labelled C) and a ridge of older, acoustically transparent sediments. The surface of the terrace is smooth and appears to be highly reflective, probably similar to the Hatteras and Sohm abyssal plains. The lower continental rise, which lies between the terrace and the plains and is labelled B, is probably widely variable in reflectivity. It is characterized by numerous ridges of acoustically transparent sediment. The crests of some of the ridges form the sea floor, others are buried under turbidites. The majority of the continental rise is shown as AB; it is generally smooth, but due to the regional slope and the presence of minor irregularities does not qualify as a true A-type area.

Figure 7 is a very detailed map of an area in the eastern North Atlantic on the lower flank of the Mid-Atlantic Ridge. This area is typical of much of the ridge flank in that while overall the sea floor is quite rough, areas which are very smooth do exist. The smooth areas are ponded sediments which have slumped off the neighboring high areas and flowed into the depressions. In some places the small abyssal plains thus formed are almost perfectly level; in others they have been mildly distorted and tilted by recent tectonics. This figure was derived from a detailed grid survey made under precise (satellite) navigational control. It shows that even in such rugged regions as the ridge flanks sizable smooth areas exist where bottom loss could be expected to be quite low.

Figure 8 incorporates the boundaries as detailed in the foregoing figures and graphically portrays the overall distribution of bottom roughness in the western North Atlantic.

DISCUSSION

In a qualitative analysis such as this study, it is difficult to maintain a consistent feeling for the classification of roughness by A, B, and C types between diverse areas and especially between areas of vastly different sizes. The normal approach is to appraise the roughness within an area and then subdivide it into the three classes. If the full spectrum of roughness is represented a valid classification will be achieved, if it is not, the A, B, C class lines will be distorted.

The relative degree of detail in which the several areas of study have been delineated is difficult to ascertain or to portray; however, in general it can be visualized as directly related to the scales of the maps. The accuracy is largely dependent on the amount of ship's track available from the area; however, even in areas having close control, if the topography varies little, few boundary lines will be required, thereby giving the impression that the control in the area may be insufficient. Also, since transitions between zones frequently are extremely gradual in nature the positions of zonal boundary lines are frequently somewhat arbitrary even when close control exists.

Regarding the figures shown in this report, Figures 2 and 3 represent about the same degree of refinement; Figure 4, the largest area by far, is the least detailed; Figures 5 and 6 were studied in minute detail but are, due to the overall smoothness and the gradualness of transitions, impractical to subdivide in greater detail along macrotopographic lines; Figure 7, because of very close control, is extremely detailed; if shown on the scale of Figure 4 it would be lumped as a C area as is the rest of the Mid-Atlantic Ridge at the present state of refinement in that province.

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The authors have made use of preliminary results of investi-

gations being conducted by C. Windisch, R. Embley, H. Kagami, R. Anderson and F. Shepard.

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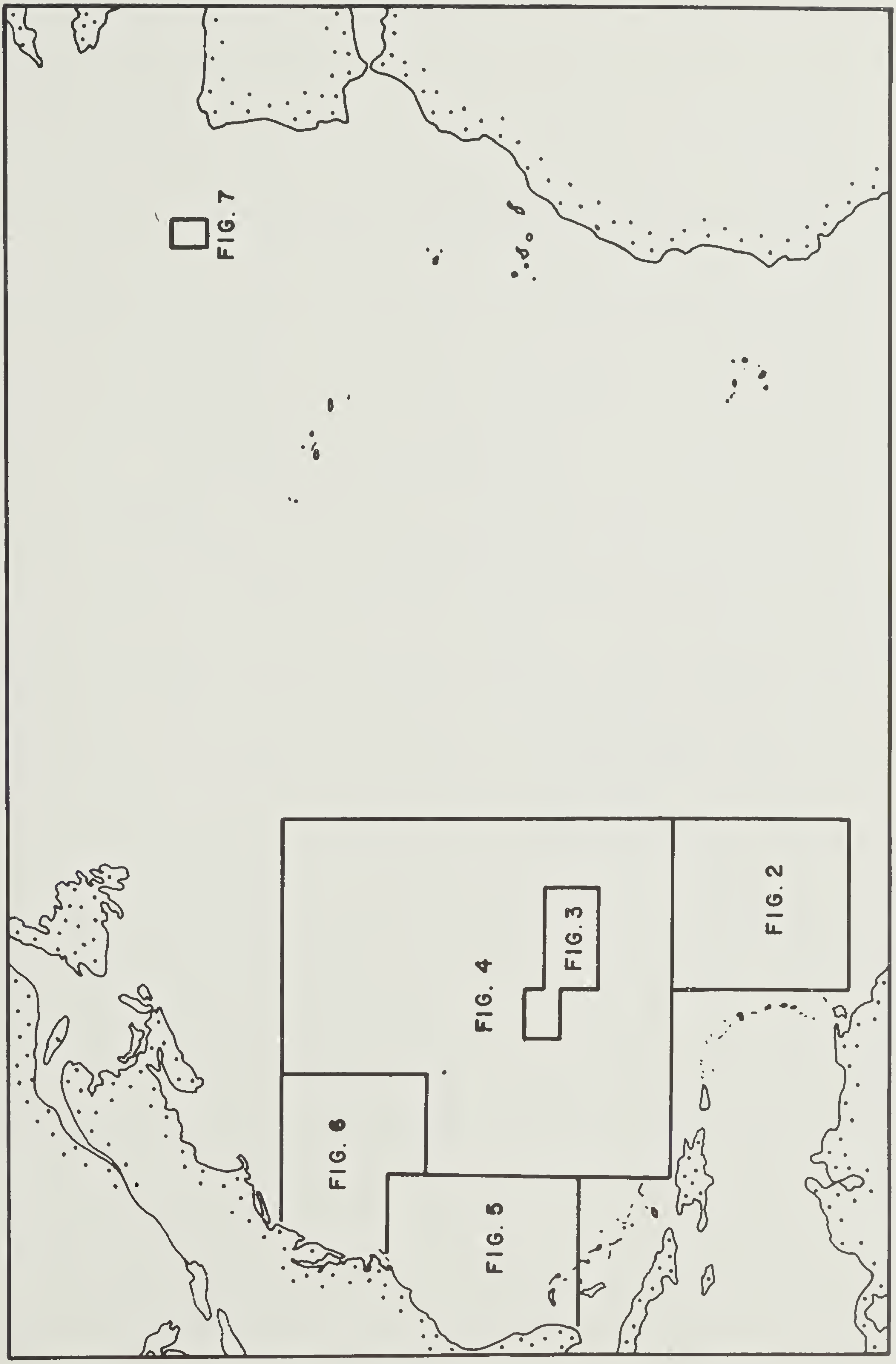

Fig. 1 Locations of the six areas studied.

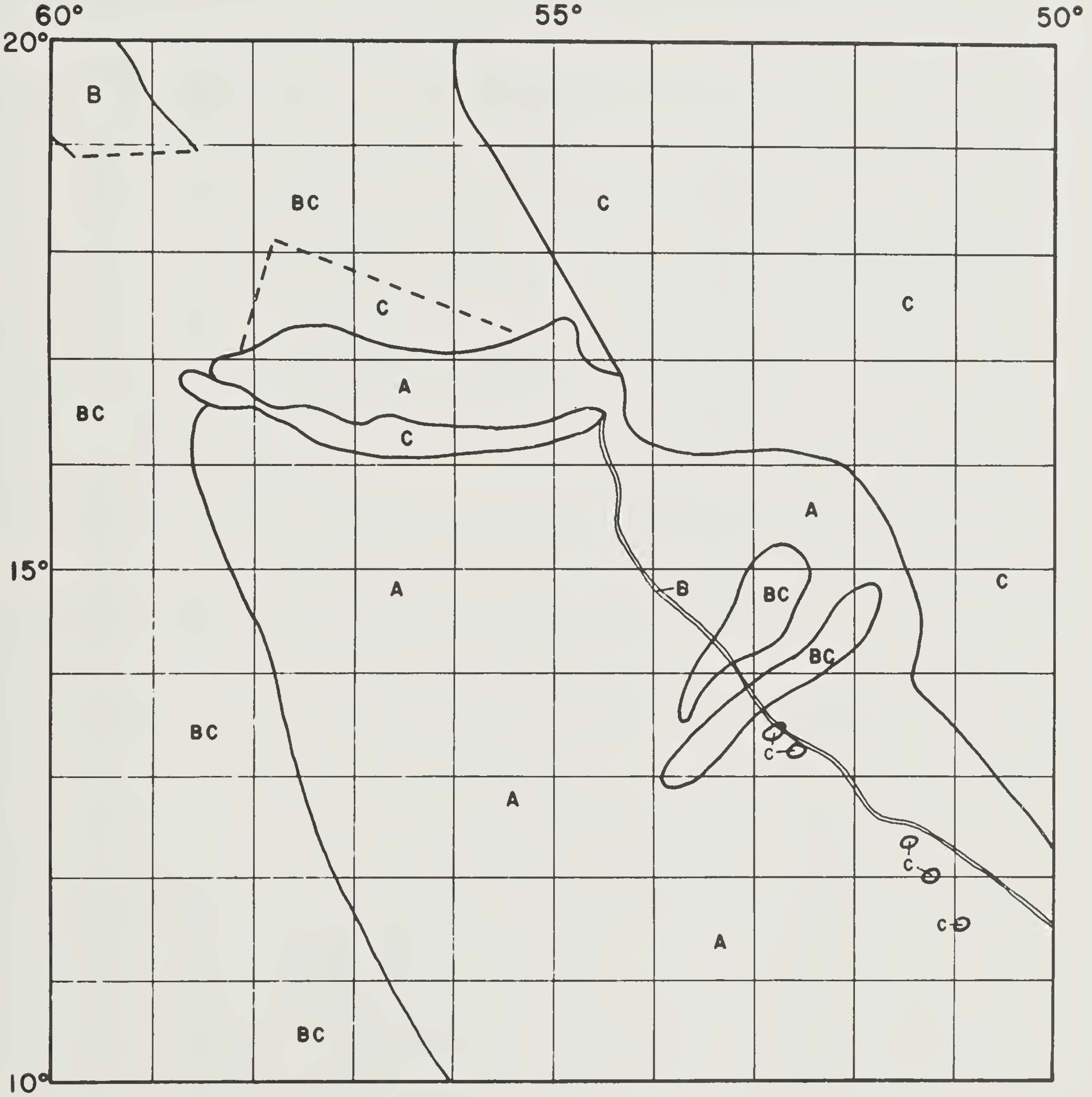

Fig. 2

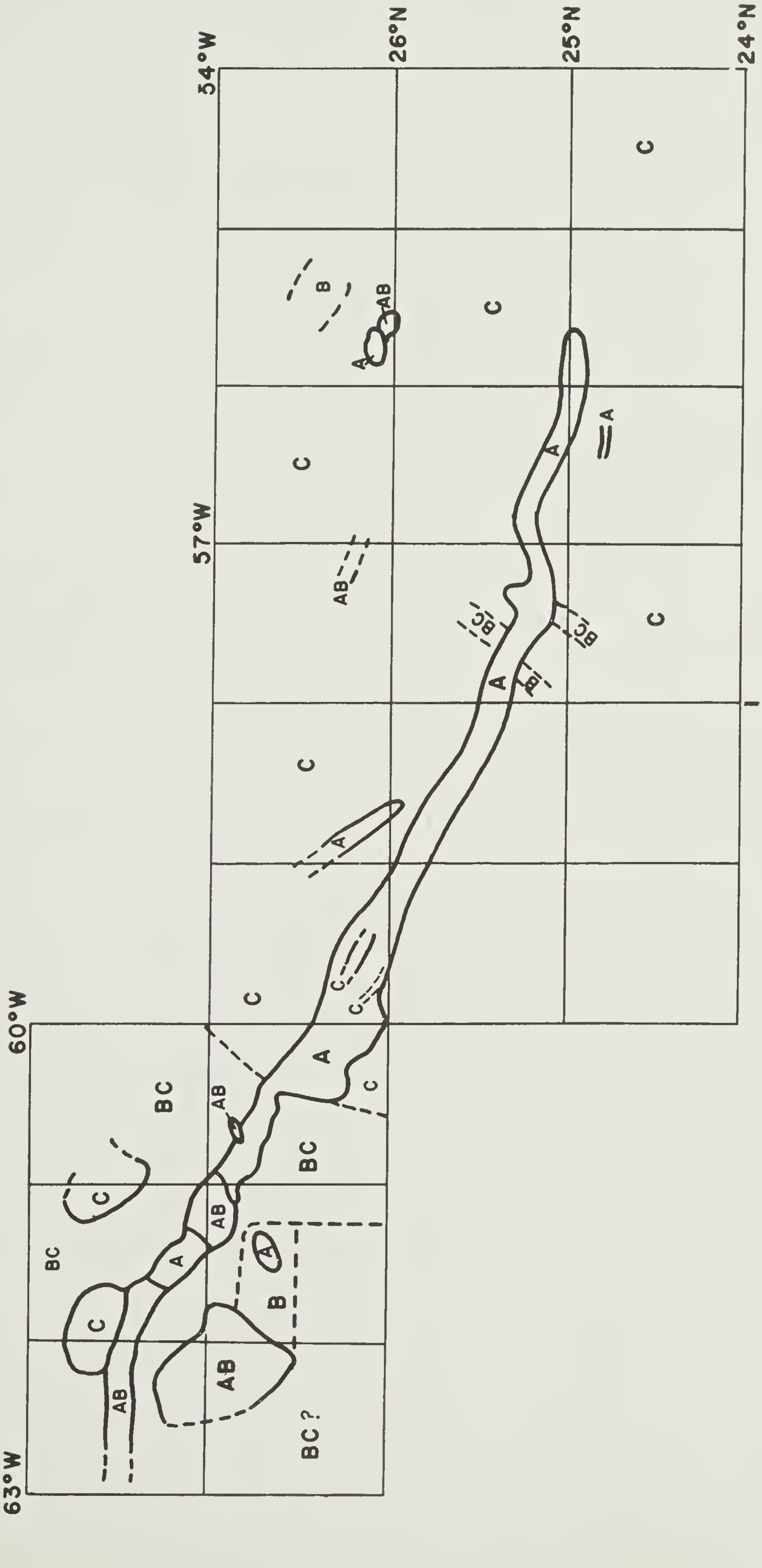

Fig. 3

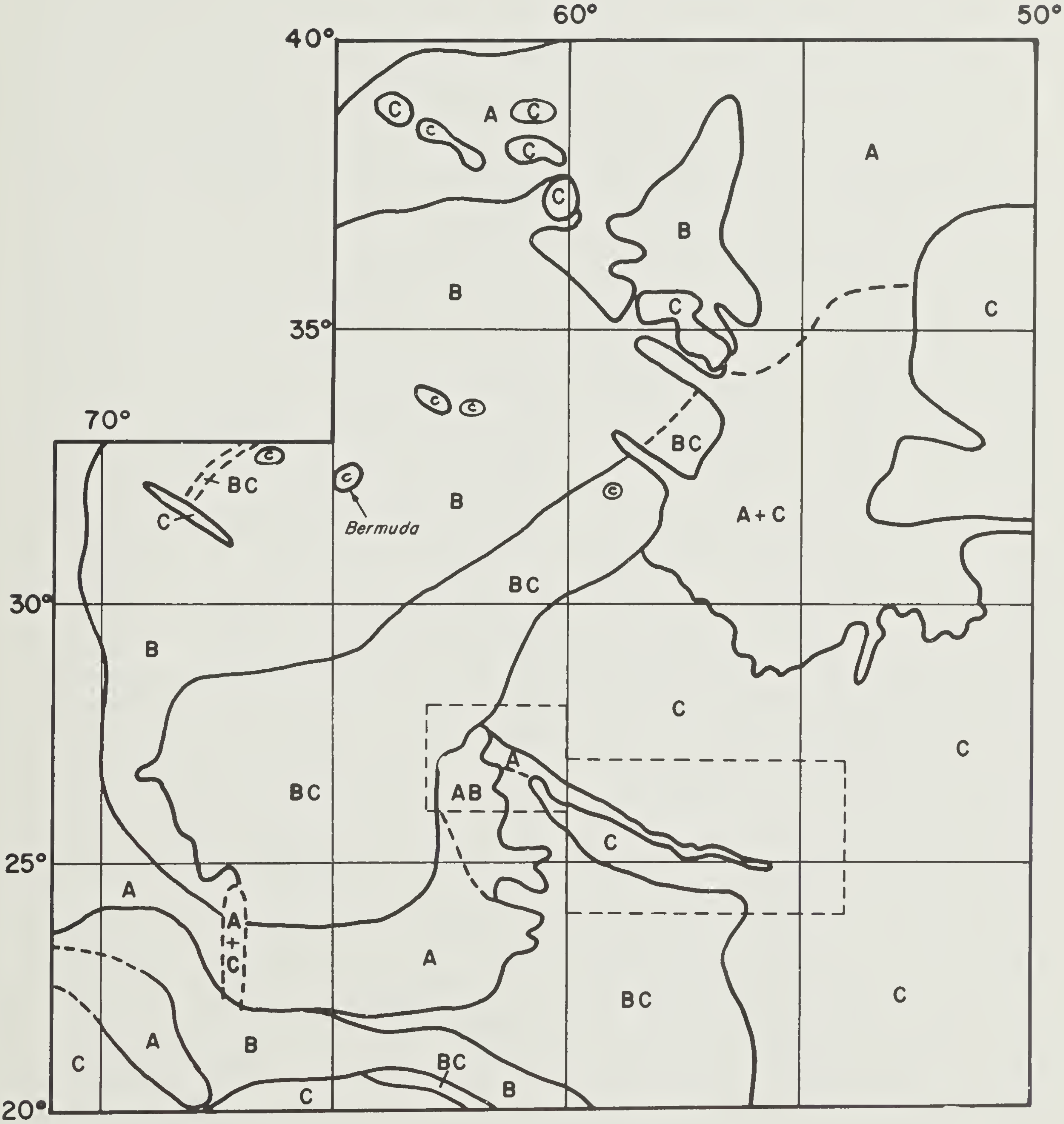

Fig. 4 Note that the area of Fig. 3 is indicated by dashed outline.

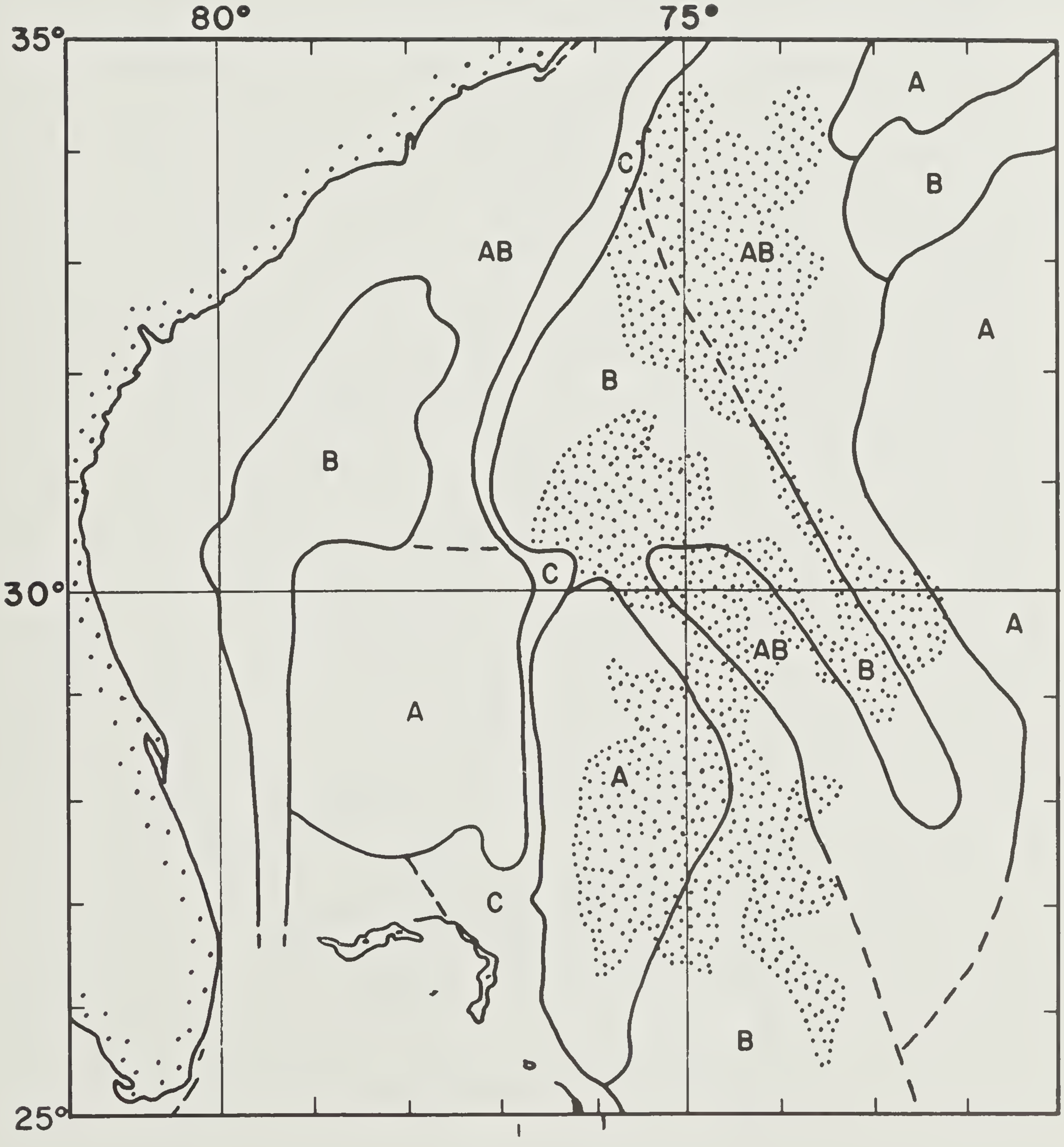

Fig. 5

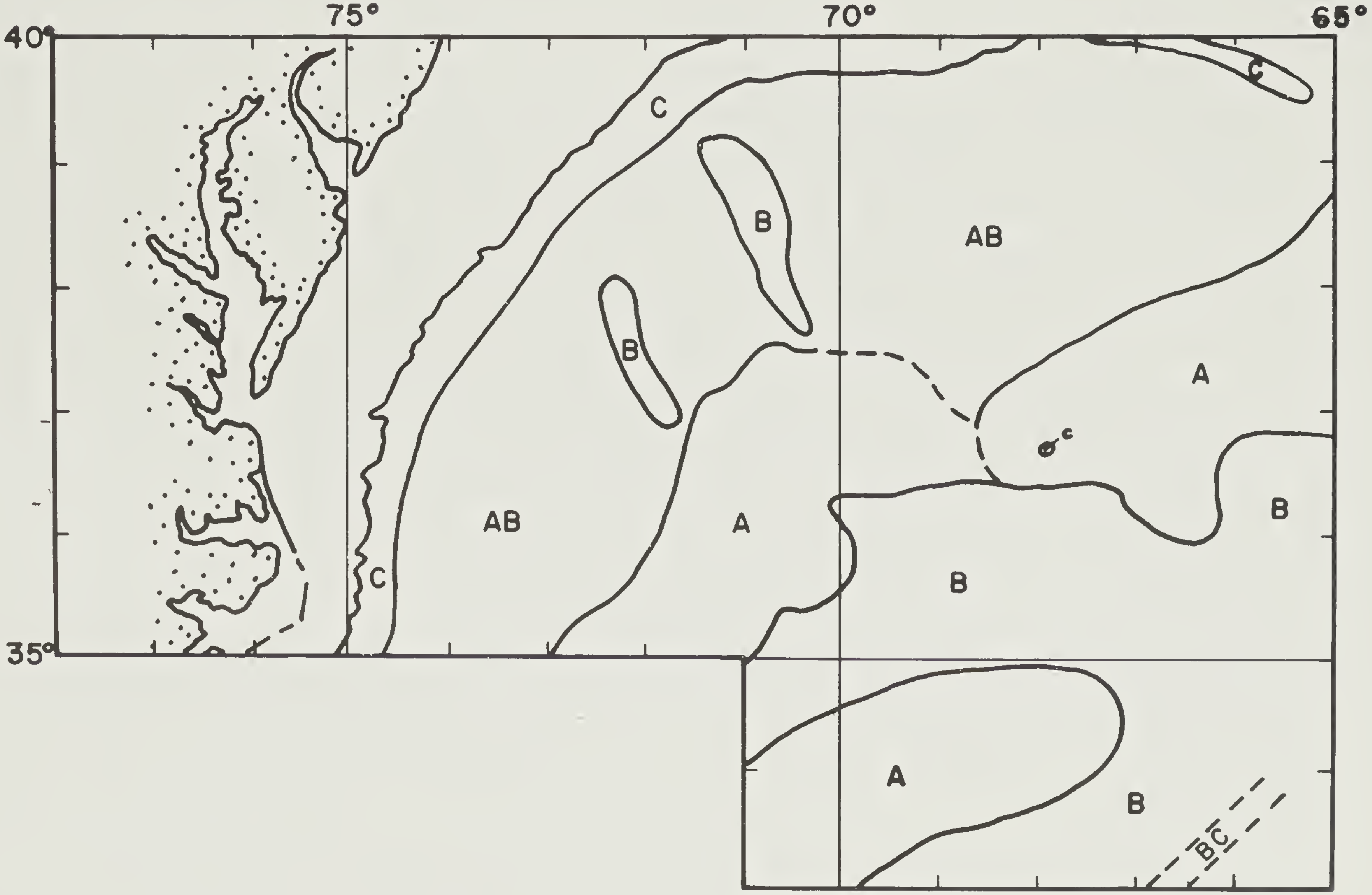

Fig. 6

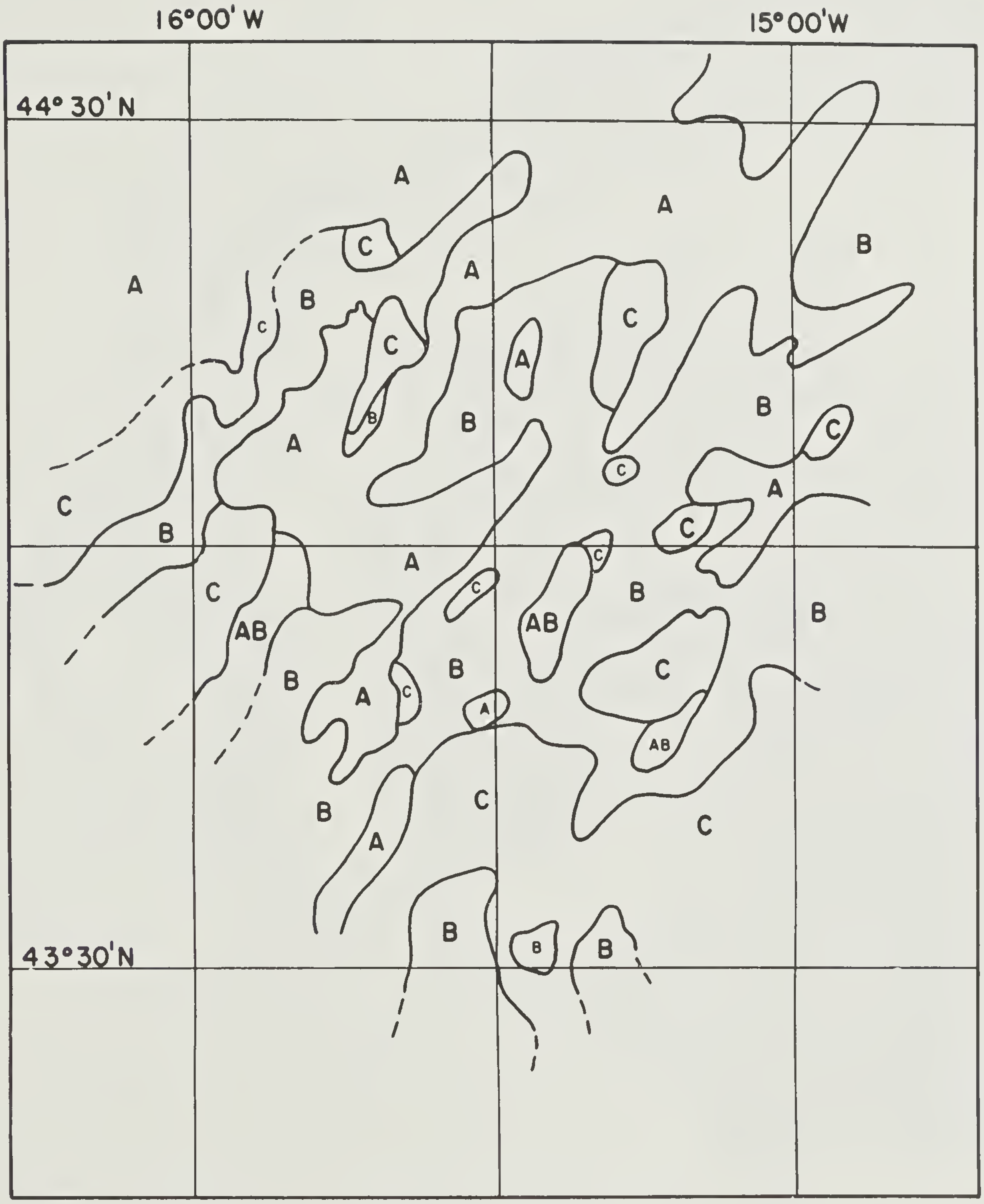

Fig. 7

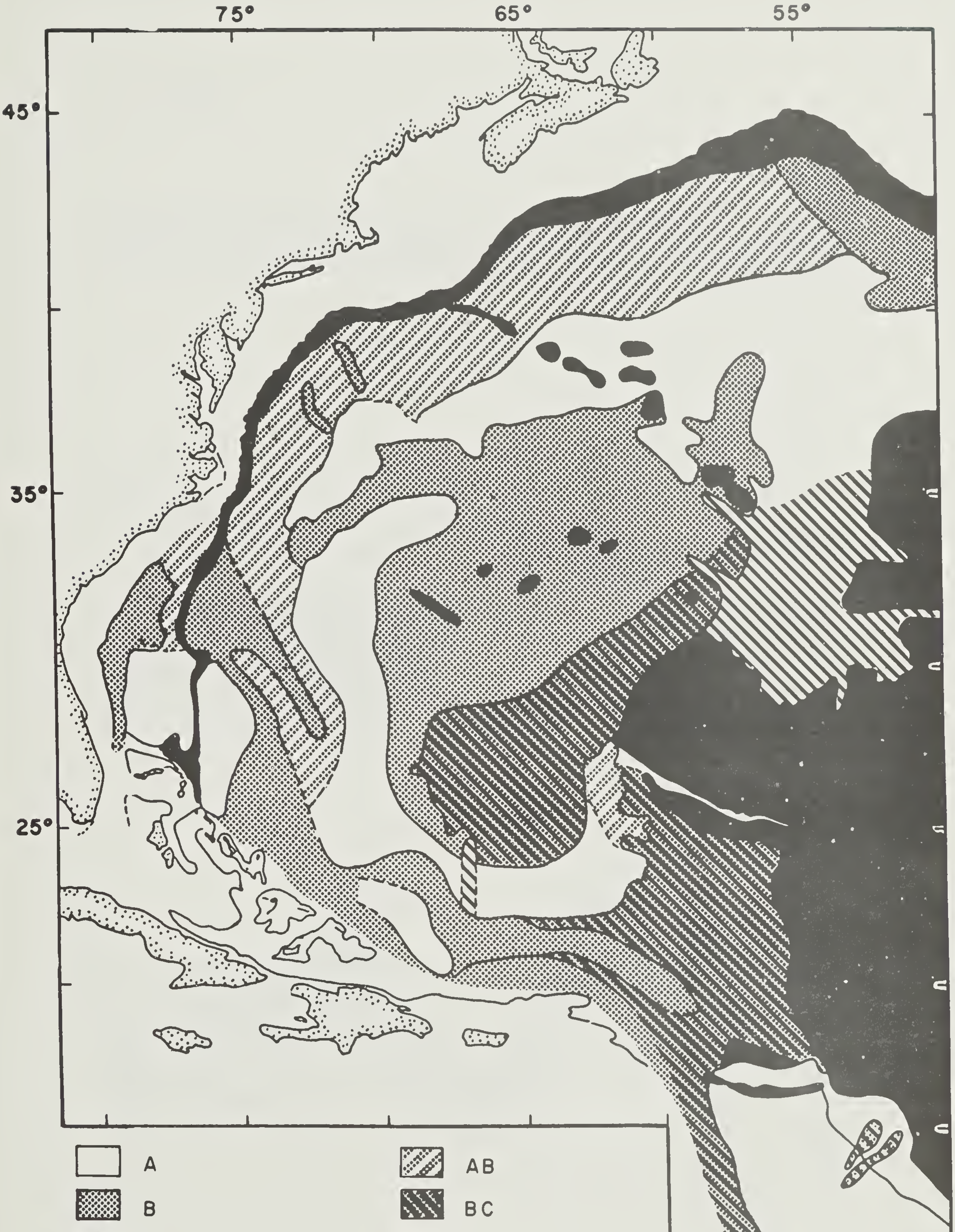

Fig. 8 Overall distribution of bottom roughness in the western North Atlantic Ocean.

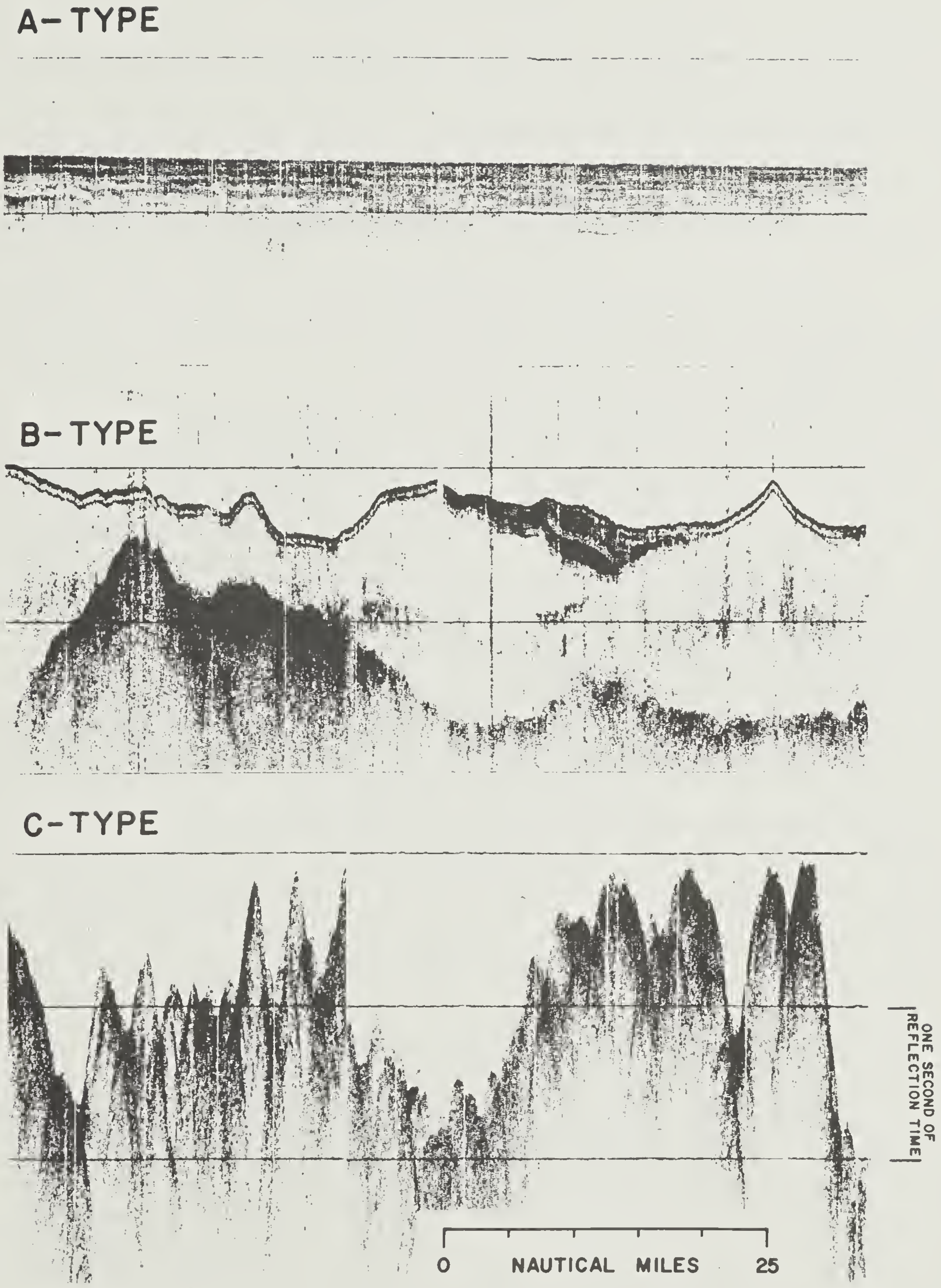

Fig. 9 Seismic reflection profiles illustrating typical A, B, and C-type topography.

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13. ABSTRACT

The range of roughness of the western North Atlantic sea floor has been assessed and subdivided, largely on the basis of 12 kc echo sounder and seismic profiler data, into three major categories. Charts delineating the areal extent of these three degrees of roughness have been made.

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